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TRANSIT TEMPERATURES OF
California Mature-Green Tomatoes Shipped by Rail

Marketing Research Report No. 349

UNITED STATES DEPARTMENT OF AGRICULTURE
Marketing Research Division ● Agricultural Marketing Service
Washington, D.C.

PREFACE

This report is part of a broad program of continuing research designed to improve efficiency and reduce costs in the marketing of farm products. The following firms and individuals cooperated in this test:

The Cochran Co., Tracy, Calif.; R. T. Cochran Co., New York, N. Y.; George Peters, Pacific Fruit Express Company, San Francisco, Calif.; J. W. Morris, Preco Inc., Los Angeles, Calif.; and D. E. MacLeod, Preco Inc., Los Angeles, Calif.

SUMMARY

Transit temperatures of mature-green tomatoes were compared in a conventional ice-bunker car equipped with electric fans, a Cargotemp car, and a mechanically refrigerated car. The Cargotemp car is a modified ice-bunker car equipped with a small diesel engine to power thermostatically controlled fans.

Loads in all the cars were heavy enough to qualify for reduced freight rates.

Temperatures fluctuated more in the conventional car than in the other two cars and approached the chilling point (50° F.) in the coldest positions in the load. Temperatures in the Cargotemp and mechanically refrigerated cars remained close to the thermostat settings of 55° F.

Ripening in transit in the Cargotemp and mechanical cars was uniform and sufficient to permit marketing within a few days of arrival at the terminal market. The colder temperatures in the conventional car retarded ripening and reduced the percentage of salable fruit.

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INTRODUCTION

New types of railroad refrigerator cars in service or under road test for fresh fruits and vegetables make it desirable to determine the ability of such equipment to keep various commodities at desired temperatures during transit. Some crops need transit temperatures only slightly above their freezing points, but others require temperatures well above the freezing point to prevent injury by chilling.

The test described in this report was conducted to compare the rates of initial cooling and the subsequent transit temperatures of mature-green tomatoes shipped in a conventional ice-refrigerated car, a "Cargotemp" (modified ice-bunker) car, and a mechanically refrigerated car.

Because tomatoes are sensitive to cold, prolonged exposure to temperatures below 50° F. causes chilling injury which adversely affects ripening and increases decay. Temperatures between 55° and 65° prevent such injury without increasing the incidence of decay.[2] The aim of this test, therefore, was to obtain transit temperatures within this safe range in all the cars.

TEST PROCEDURE

Railway Equipment

As a check for comparison with the new types of available railway equipment, a conventional ice-bunker car equipped with electric fans was used as one of the test cars (see table 1 for specifications).

The "Cargotemp" car was a modified ice-bunker car that was equipped with a small diesel engine to provide power to operate the fans whenever refrigeration was needed. Movement of refrigerated air through the ice bunkers was controlled by thermostatically activated fans and louvres. An additional fan in each end of the car continuously circulated the air within the load compartment (table 1).

The mechanically refrigerated car used in this test had an air circulating system essentially of "semi-envelope design with ceiling supply"[3] in which the cooled air was discharged through a plenum at the ceiling. The ceiling was perforated to permit approximately 20 percent of the air to blow down on top of the load while 80 percent passed down flues at the sides and end of the car to openings at the floor level. All return air was drawn from under the floor rack to the coil bunker (table 1).

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[1] Mr. Barger, horticulturist, and Mr. Harvey, senior plant pathologist, are stationed at Fresno, Calif.; Mr. Ringel, plant pathologist, is stationed in New York City.

[2] McCulloch, L. P., and Pentzer, W. T. Refrigeration of Tomatoes in Transit. Pre-Pack-Age 6(1): 11-14. 1952
Barger, W. R., Radspinner, W A., and Morris, L. L. U. S. Dept. Agr. Handling, Transportation & Storage Rpt. No. 317. July 1954.

[3] Amer. Soc. Refrig. Engin. Data Book 1959. Vol. 1, pp. 33-11. New York, N. Y.

Table 1.--Specifications, loading patterns, and types of refrigeration in 3 cars used for test shipments from Tracy, Calif., to New York, October-November 1958

Specifications and loading pattern	Type of refrigeration in car		
	Conventional	Cargotemp	Mechanical[1]
Specifications			
Inside width	8' 3"	8' 3"	8' 3"
Inside length	33' 3"	33' 3"	35' 3"
Insulation:			
Wall	6"	4"	6"
Roof	8"	4-1/2"	8"
Refrigeration	Ice	Ice	Mechanical
Capacity:			
Full bunker	11,500 lb.	11,500 lb.	8 tons per day
Half stage	6,000 lb.	6,000 lb.	
Air circulation	Electric fans	Electric fans[2]	Electric blower
Rating	9,000 c.f.m. at 60 m.p.h.	9,000 c.f.m. from ice bunkers, controlled by thermostat. 3,000 c.f.m. through bypass	4,000 c.f.m.
Power (primary)	Car axle	5 hp diesel engine	18 hp diesel engine
Thermostatic control	No	Yes	Yes
Loading pattern[3]			
Rows wide	5	5	5
Layers high	7	7	7
Stacks long	26	26	28
Total lug boxes	910	910	980
Billed weight	34,580 lb.	34,580 lb.	37,240 lb.

[1] Semi-envelope design with ceiling supply in which 20 percent of the cold air blast enters load compartment through holes in ceiling plenum.

[2] One fan in each end of car in continuous operation for circulation of air in body of car. Two fans in each end of car controlled thermostatically to circulate air from the ice bunkers.

[3] Wrapped tomatoes in lidded lugs approximately 13-1/2 by 16-1/8 by 6-7/16 inches in on-bottom, crosswise, divided loads with gate type spacers between stacks and center-gate bracing at doorway. Building paper was placed over floor rack at doorway to prevent by-passing of air at center bracing.

Loads

The cars were loaded with mature-green Pearson tomatoes harvested from a single field and individually wrapped and packed in standard No. 1025 lidded, wooden lug boxes measuring approximately 13-1/2 x 16-1/8 x 6-7/16 inches.

As the lug boxes were stacked seven high in the cars, all loads were heavy enough to qualify for reduced freight rates. Billing weights of the Cargotemp and conventional cars were 34,580 pounds each and that of the mechanical car was 37,240 pounds. Loads were similar in width and height and in loading pattern, but differed in length since the extra length of the mechanical car accommodated two additional stacks (table 1).

Protective Services

Average tomato temperatures at loading ranged from 61° to 63° F. In accordance with a schedule developed for this crop,[4] the conventional car was shipped under modified refrigeration with an initial icing of 1 ton in each bunker and one re-icing in transit of an additional ton in each bunker, under Tariff Rule 247.[5]

The Cargotemp car was also shipped under Rule 247 but was intentionally iced above the amount required for tomatoes that were moderately cool at loading, in order to test the effectiveness of the thermostat in maintaining transit temperatures close to 55° F. when a large reserve of ice was provided. Ice meltage in transit is shown in table 2.

The mechanically refrigerated car was shipped under Rule 171 with thermostat set at 55° F.[6]

Temperature Measurements

Transit temperatures of tomatoes were recorded with thermometers placed in the tomato boxes near the centerline of the cars. Two thermometers were used in each of the bottom, middle, and top layers of the loads to determine the spread in temperature between the ice bunker and the doorway. Air temperatures were recorded above the loads approximately halfway between the ice bunker and the doorway (quarterlength position).

Test Packages

In order to compare the amount of ripening in transit in the 3 cars and to correlate transit temperatures with the subsequent condition of the fruit at the market, test packages of tomatoes were placed at the same positions as the recording thermometers. Test packages were recovered and the fruit was inspected for ripeness and decay when the cars were unloaded at New York and after holding at 70° F. for further ripening.

Meanwhile, additional samples of fruits from the test lots were ripened at 68° to 70° in California to determine ripening potential separately from the effect of transit refrigeration.

Routing

The cars were loaded at Tracy, Calif., October 27, 1958, and routed over the Southern Pacific, Union Pacific, Wabash, and Pennsylvania Railroads. They arrived at the Jersey City terminal yards at 10 p.m., November 3, and subsequently were moved to New York City for unloading at different times between November 9 and 17. The running time was similar to the new fast schedule formally inaugurated by the railroads on November 1, 1958.

RESULTS AND DISCUSSION

Tomato temperatures in the top, middle, and bottom layers of the loads in all cars were mostly above 50° F., the danger point for chilling injury, during the transit period (October 27 to November 3, fig. 1).

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[4] U. S. Dept. Agr. Shipping Temperatures for Tomatoes. Agr. Mktg. Serv. PA-290. July 1956.

[5] Rule 247 (National Perishable Freight Committee Perishable Protective Tariff 17) calls for initial icing, with 1 or 2 re-icings in transit.

[6] Rule 171 (National Perishable Freight Committee Perishable Protective Tariff 17) provides mechanical refrigeration at the same cost as standard refrigeration for ice-bunker cars.

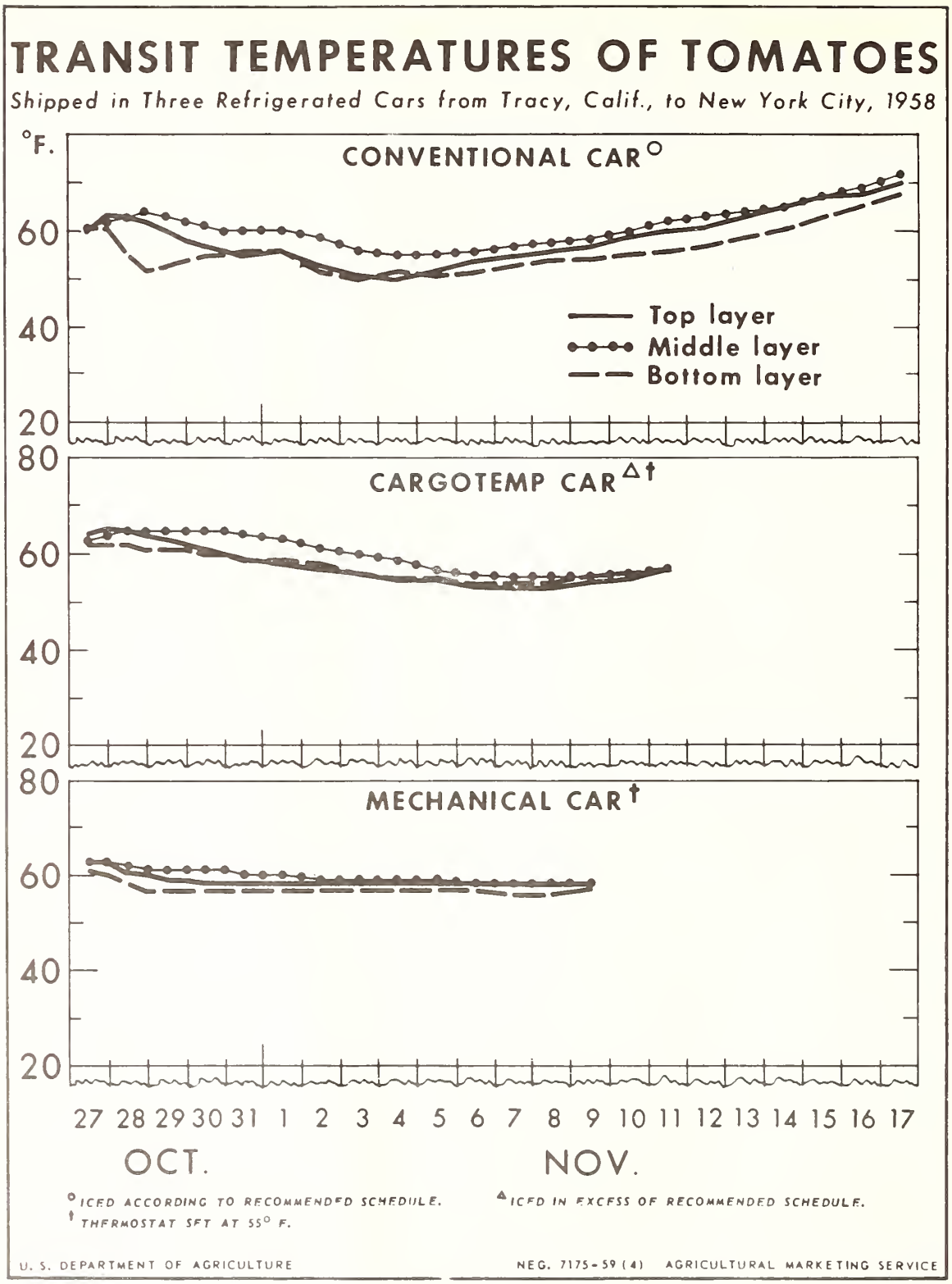
TRANSIT TEMPERATURES OF TOMATOES
Shipped in Three Refrigerated Cars from Tracy, Calif., to New York City, 1958
°F.
CONVENTIONAL CAR°
Top layer
Middle layer
Bottom layer
CARGOTEMP CAR△†
MECHANICAL CAR†
80
60
40
20
27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
OCT.
NOV.
°ICED ACCORDING TO RECOMMENDED SCHEDULE.
†THERMOSTAT SET AT 55° F.
△ICED IN EXCESS OF RECOMMENDED SCHEDULE.
U. S. DEPARTMENT OF AGRICULTURE
NEG. 7175-59 (4) AGRICULTURAL MARKETING SERVICE

Figure 1

Table 2.--Ice supply in ice bunker cars and average temperature of tomatoes in 3 test cars at indicated stations between Tracy, Calif., and New York City, 1958

Date	Station	Time	Type of refrigeration in car				
			Conventional, no thermostatic control		Cargotemp, thermostat set at 55° F.		Mechanical, thermostat set at 55° F.
			Ice	Av. temp. tomatoes	Ice	Av. temp. tomatoes	Av. temp. tomatoes
				°F		°F	°F
Oct. 27...	Tracy.....	3:00 p.m.	4,000 lb. initial	61.0	6,000 lb. initial	63.0	62.0
30...	Ogden.....	3:00 a.m.	None remaining	57.3	2,500 lb. remaining	62.5	58.7
30...	Laramie.....	10:00 p.m.	None remaining	57.0	1,000 lb. remaining	62.0	58.2
Nov. 1...	Kansas City....	1:20 a.m.	None remaining	55.9	800 lb. remaining	58.0	58.0
			4,000 lb. added		5,200 lb. added		
3...	Jersey City arr.	10:00 p.m.	No inspection	52.5	No inspection	57.0	57.8
5...	Jersey City....	---	None remaining	53.5	3,500 lb. remaining	55.5	57.5
9...	New York City, unload.	7:00 p.m.	---	---	---	---	56.0
11...	New York City, unload.	8:00 p. m.	---	---	None remaining	60.0	---
17...	New York City, unload.	8:00 p.m.	None remaining	69.0	---	---	---

Conventional Car

Optimum transit temperatures for tomatoes (55° to 65° F.) were obtained in the middle layer of the conventional car, but the icing schedule, which called for supplying 1 ton in each bunker at Tracy and 1 ton in each bunker at Kansas City (table 2), resulted in undesirably low temperatures in other parts of the load. In the top layer of boxes the tomatoes cooled at a satisfactory rate to 55° F. from Tracy to Kansas City, but continued to cool to a point close to 50° after the car was re-iced at the latter station. Also, in the bottom layer of boxes, tomato temperatures dropped from 61° to 52° during the first day in transit and from 56° to 50° after re-icing at Kansas City (fig. 1). A gradual rise in temperature from 52° to 56° followed the depletion of the initial ice supply.

The spread in temperature between the warmest and coldest tomatoes in the load was usually about 5° F. during most of the transit period. This difference was no greater than that recorded in previous tests in which five-layer loads were used (see footnote 2). There was no evidence from the current test that the tomatoes in seven-layer loads suffer from lack of adequate refrigeration.

Cargotemp Car

Tomato temperatures in the top, middle, and bottom layers of the Cargotemp car were satisfactory. With a pulp temperature of 63° F. at the time of loading, the fruit was maintained between 55° and 65° during the entire transit period (October 27 to November 3, fig. 1) despite the heavy initial icing at Tracy and excessive re-icing at Kansas City. The slightly slower rate of cooling in this car than in the others (fig. 2, average of load) indicates that the bunker fans were turned off by the thermostat very early in the trip.

The differential in fruit temperatures through the load was not over 5° F. at any time in transit and narrowed to 2° during most of the time the car was held on track at the market.

Mechanical Car

Good transit temperatures were obtained in the mechanical car. All layers of the load were cooled in a reasonably short time to a point close to the thermostat setting of 55° F. and remained at this temperature for the balance of the trip (fig. 1).

The temperature differential in this car ranged from 2° to 4° with a 2° split prevailing most of the time.

Air Temperature

Air temperature above the loads ranged from 40° to 50° F. (transit period) in the conventional car, 50° to 56° in the Cargotemp car, and 55° to 56° in the mechanical car (table 3). It fluctuated more in the conventional car than in the Cargotemp and mechanical cars, but not to an objectionable degree.

Temperatures During Holding on Track at Terminal

Due to marketing conditions and lack of ripening in the tomatoes at arrival, the cars were held on track at the market for 6 to 14 days by the receiver.

Fruit temperature in the conventional car, with fans off and ice bunkers dry during the holding period, rose gradually from an average of 52.5° F. at arrival to 69° on unloading day, November 17. This rise in temperature was due largely to the heat of respiration generated by the fruit, since the daily average temperature outside the car was below 50° (table 3).

The temperature of the load in the Cargotemp car was maintained close to the thermostat setting of 55° F. for the 8 days it was held on track (fig. 1). During this time the air circulating unit was kept in operation and sufficient refrigeration was obtained from the 3,500 pounds of ice in the bunkers at arrival to protect the load from overheating without supplying additional ice.

Temperatures were maintained close to the thermostat setting in the mechanical car during the 6 days it was held on track (fig. 1).

Condition on Arrival

The condition of the tomatoes in the commercial part of the loads as reported by the receiver soon after the cars arrived at the market and as reported by the Railroad Perishable Inspection Agency at the time the cars were unloaded is shown in table 4.

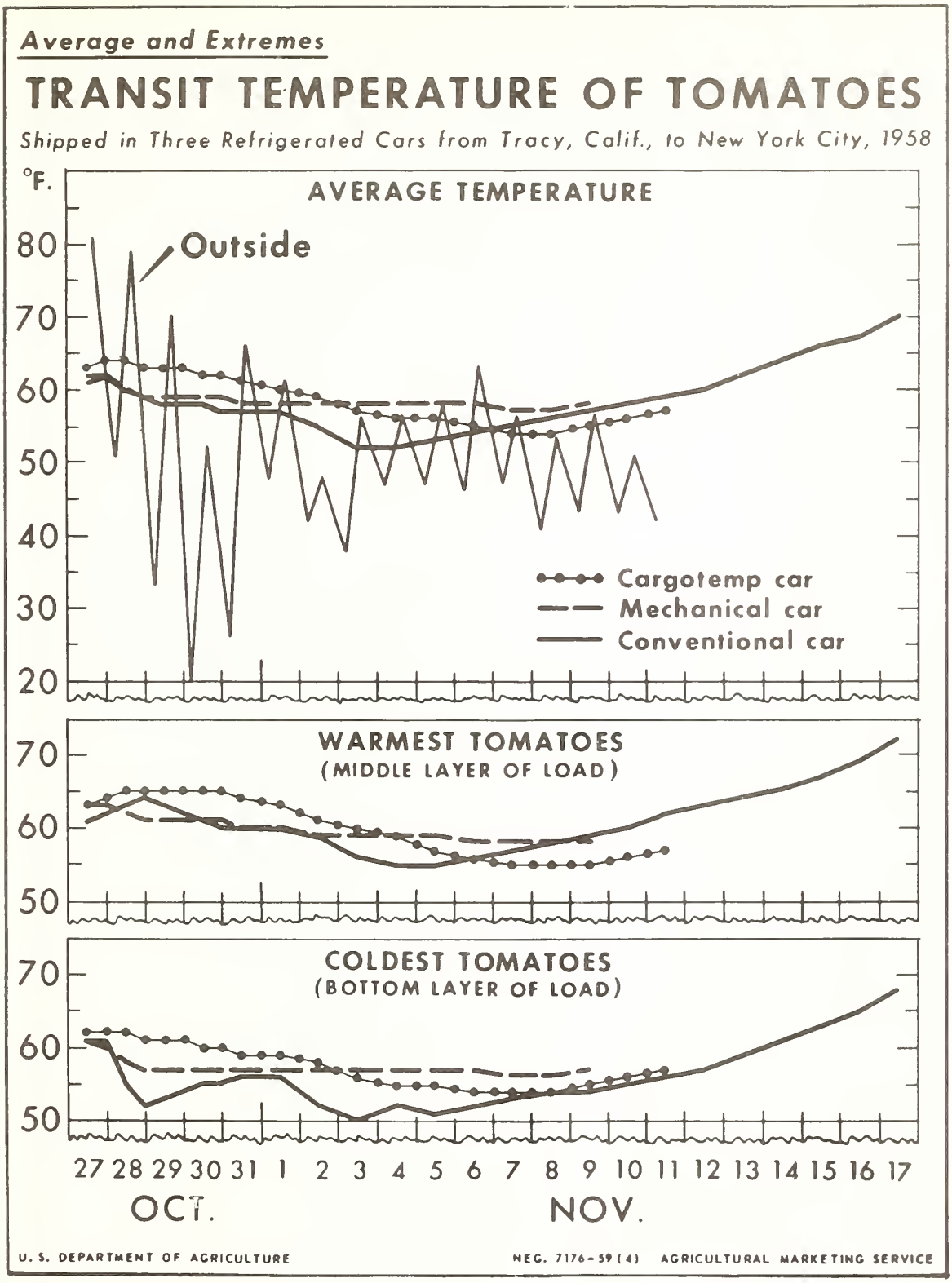
Average and Extremes
TRANSIT TEMPERATURE OF TOMATOES
Shipped in Three Refrigerated Cars from Tracy, Calif., to New York City, 1958
°F.
AVERAGE TEMPERATURE
Outside
80
70
60
50
40
30
20
Cargotemp car
Mechanical car
Conventional car
WARMEST TOMATOES
(MIDDLE LAYER OF LOAD)
70
60
50
COLDEST TOMATOES
(BOTTOM LAYER OF LOAD)
70
60
50
27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
OCT.
NOV.
U. S. DEPARTMENT OF AGRICULTURE
NEG. 7176-59 (4) AGRICULTURAL MARKETING SERVICE

Figure 2

Table 3.--Air temperature above loads (quarterlength position) and outside of test cars of tomatoes during transit from Tracy, Calif., to Jersey City, N. J., 1958

Date	Station	Above loads			Outside		
		Conventional car	Cargotemp car	Mechanical car	Minimum	Maximum	Average[1]
		°F	°F	°F	°F	°F	°F
Oct. 27...	Tracy[2].....	70	77	75	---	81	65
28...		50	56	55	51	79	60
29...		45	54	56	33	70	45
30...	Ogden.....	42	53	56	20	52	31
31...	Laramie.....	50	52	56	26	66	40
Nov. 1...	Kansas City[3].....	50	52	56	48	61	51
2...		40	51	56	42	48	44
3...	Jersey City.....	46	50	56	38	56	44
4...		49	49	56	47	56	50
5...		52	50	57	47	58	51
6...		54	50	58	46	63	52
7...		56	51	58	47	56	50
8...		56	53	58	41	53	45
9...		57	56	58	43	56	47
10...		58	56	---	43	51	46
11...		end of record	---	---	42	---	---

[1] Weighted on basis of 8 hours at maximum and 12 hours at minimum.
[2] Cargotemp and conventional cars initially iced at 3 p.m.
[3] Cargotemp and conventional cars reiced at 1:20 a.m.

The fruit in the conventional car arrived green and was held on track 2 weeks before it was considered ready for sale. The fruit in the Cargotemp and mechanical cars developed some red color in transit and was sold within 6 to 8 days after arrival. Although the average temperatu: of the tomatoes during the transit period did not differ much between cars (58° to 61° F., table 4), it was lowest in the conventional car. The lower average transit temperature in this car, coupled with the fact that much of the fruit dropped to 50° enroute, accounts for the lack of color upon arrival at the market. Higher minimum temperatures occurring in the Cargotemp and mechanical cars (53° and 56°, respectively) and higher average transit temperatures account for the greater ripening of the fruit in these cars during transit than in the conventional car.

Holding the cars on track at the market brought the fruit to a suitable color for sale, but the extra time required for such ripening in the conventional car resulted in considerably more decay than occurred in the other cars in which temperatures were more favorable for ripening in transit.

Ripening of Test Fruit

The sample of tomatoes held in California ripened normally at 68° to 70° F., showing that no chilling injury had occurred in the field before harvest.

Table 4.--Condition of tomatoes in commercial part of loads in 3 refrigerated cars on designated dates, New York City, 1958

Item	Type of refrigeration in car		
	Conventional	Cargotemp	Mechanical
Date of loading	Oct. 27	Oct. 27	Oct. 27
Date of arrival	Nov. 3	Nov. 3	Nov. 3
Time in transit	7 days	7 days	7 days
Average temperature of tomatoes, Oct. 27 to Nov. 3	58° F.	61° F.	59° F.
Condition of tomatoes at arrival (receiver's inspections):			
Ripe	None	None	5%
Breaking	0-20%	30-50%	50-90%
Green	80-100%	50-70%	5-50%
R.P.I.A.[1] inspections at unloading:			
Date	Nov. 17	Nov. 11	Nov. 9
Time in car	21 days	15 days	13 days
Average temperature of tomatoes, Oct. 27 to unloading	59° F.	58° F.	59° F.
Condition of tomatoes:			
Soft ripe	1-1/3%	2-2/3%	1-1/3%
Firm ripe	31-1/3%	24-1/3%	20%
Turning	51%	56-2/3%	47-2/3%
Green	6-1/3%	16%	31-1/3%
Decay	10%	2/3%	1-2/3%

[1] Railroad Perishable Inspection Agency.

Since the cars were held on track at the market for different lengths of time before unloading, direct comparisons between cars of the outturn of the test fruit was impossible. However, comparison on ripeness at the time of unloading and on the subsequent outturn of the fruit with respect to in-car time and temperature is of interest (tables 5 and 6).

The average temperatures of the tomatoes from loading to unloading were similar for all cars (58° to 59° F.). Consequently the increase in percentage of ripe fruits in the conventional car at time of unloading over that in the other cars appears to be due mainly to the length of time the tomatoes remained in this car (21 days) (table 5). Decay was also greatest in the conventional car because of the long holding period on track.

During subsequent ripening at 70° F. at the market, the percentage of passable and good fruits when ripe was considerably higher in the lots shipped in the mechanical and Cargotemp cars than in the lot from the conventional car (table 6). Some culled fruit from the conventional car showed slight evidence of chilling, indicating that transit temperatures should be kept above 50° for late fall shipments of tomatoes.

Table 5.--Condition of test tomatoes on day following unloading from 3 refrigerated cars, New York City, 1958

Item	Type of refrigeration in car		
	Conventional	Cargotemp	Mechanical
Date of inspection	Nov. 18	Nov. 12	Nov. 10
Time in car	21 days	15 days	13 days
Average temperature of tomatoes while in car	59° F.	58° F.	59° F.
Condition of tomatoes on date of inspection:			
Ripe	35%	15%	9%
Advanced	27%	15%	13%
Medium	27%	27%	21%
Slight	10%	27%	40%
Green	1%	16%	17%
Total	100%	100%	100%
Decay	3.9%	1.6%	0.6%

Table 6.--Salability of test tomatoes ripened at 70° F. after unloading from 3 refrigerated cars, New York City, 1958

Item	Type of refrigeration in car		
	Conventional	Cargotemp	Mechanical
Time in car from Oct. 27	21 days	15 days	13 days
Time in ripening room at 70° F.	7 to 10 days	13 to 16 days	15 to 18 days
Salability of fruit when ripe:			
Good	22%	31%	32%
Passable	66%	62%	62%
Cull	8%	5%	5%
Decay	4%	2%	1%

CONCLUSIONS

The results of this test show that modern railway refrigerator cars provide adequate refrigeration for heavy (seven-high) loads of mature-green tomatoes. The most desirable transit temperatures for this commodity can be obtained more easily in a mechanical car or in a Cargotemp car than in a conventional electric fan car.

The main advantage of shipping tomatoes in mechanical cars or in Cargotemp cars is that the moderate temperatures desired for tomatoes can be obtained thermostatically, thus eliminating the risk of chilling injury by over-refrigeration in transit.

The importance of maintaining transit temperatures above 50° F. for late fall shipments of mature-green tomatoes is definitely shown by the higher percentage of salable fruit in the cars held several degrees above this temperature than in the car in which transit temperature dropped to 50°.

* U.S. GOVERNMENT PRINTING OFFICE : 1959 O—512241